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Electric motorcycles, keys to electric mobility in Colombia

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Extended abstract:

The transport sector has become one of the pillars of economic growth and cultural development in today's societies, but the transport sector is among the main ones responsible for environmental problems such as the accumulation of GHG (greenhouse gases), deterioration of air quality in cities due to particulate matter (UPB & AMVA, 2019), and intensive use of non-renewable energy sources (IEA, 2019a).

Colombian cities face the challenge of improving air quality and transportation is one of the priority sectors for Colombia in the objectives of GHG reduction and mitigation of climate change. And in that sense, electric vehicles have become popular. Nonetheless, until now, international reports and a vast part of the research reported in the literature only have prioritized electric cars and public vehicles such as buses, leaving aside other types of vehicles (IEA, 2020).

This omission is of particular interest in developing countries, where the adoption of electric vehicles has its characteristics and problems. In Colombia, the car does not represent the predominant type of vehicle in the vehicle fleet in the country and still presents significant barriers such as initial investment and development of the charging network (BID, 2019b, 2019a). Motorcycles (scooters or other two-wheel motorbikes) are the true protagonists in the mobility of Colombia. Because of their low cost compared to the car and the mobility advantages due to its size, the motorcycles are a work item by a large part of the Colombian population, especially by the strata middle and low. But, although motorcycles outnumber cars in Colombia, the National Strategy of Electric Mobility of the country does not contemplate specific policies for motorcycles (MinAmbiente, 2019).

To study the dissemination of electric motorcycles and define scenarios for the transition to electric mobility is a basic input for making political decisions. Modeling electric motorcycles diffusion using system dynamics allows to formally simulate the system behavior and use the results for designing policies that take advantage of the leverage points (Sterman, 2000). In this work, we modeled the

diffusion of electric motorcycles in Colombia using system dynamics and following the iterative steps suggested by Sterman (2000).

The model has four interconnected modules: 1) motorcycle inventory dynamics, 2) attractiveness electric motorcycles, 3) charging points, and 4) electricity consumption and emissions. We use two main assumptions in the simulation: 1) the diffusion process of electric motorcycles can be modeled with a Bass diffusion model (Bass, 1969) and 2) the purchase decision between an electric motorcycle and a combustion motorcycle can be modeled from a multinomial logit model where the buyer evaluates characteristics such as costs, emissions, available charging points and range of the motorcycle (autonomy). We classified the motorcycles into two "technologies": motorcycles powered by an internal combustion engine (ICE motorcycles) and electric motorcycles. The simulation was implemented in Powersim Studio 10 with an annual simulation step between 2016 and 2050 (UPME, 2020). And we evaluated two policies: one focused on the *replacement* to existing motorcycles, and the other focused on advertising and incentivizing the new motorcycles purchases to motivate *imitation* (to increase the popularity and number of electric motorcycles in circulation leads people to rely more on technology and "imitate" the market choosing the electric alternative). Figure 1 shows the results.

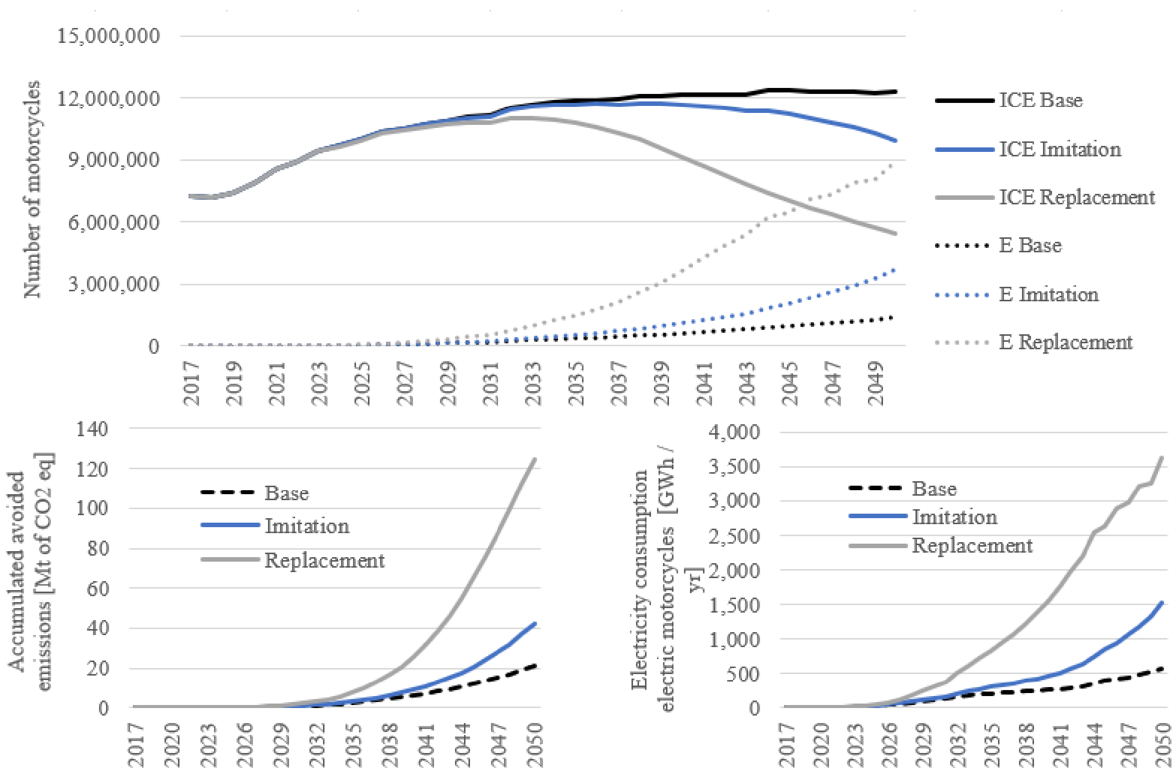

Figure 1. Number of motorcycles, avoided emissions and electricity consumption results for the simulation model. ICE: internal combustion engine motorcycles, E: electric motorcycles.

The model indicates that energy transition policies and incentives determine the speed of the penetration of electric mobility. In the base scenario, electric motorcycles reach 17% of the total vehicle fleet for 2050, a number below the national scenarios. The replacement policy would achieve that in 2032 the electric motorcycles purchases exceed the combustion motorcycles purchases and in this policy scenario, electric motorcycles would reach 63% of the total vehicle fleet for 2050. On the other hand, the imitation policy would achieve that the electric motorcycles purchases exceed the combustion motorcycles purchases in 2045 and electric motorcycles reach 31% of the total vehicle fleet for 2050. Replacement policy scenario achieves transition goals faster and is the only scenario in which the number of electric motorcycles exceeds the combustion motorcycles, this happens in the year 2044.

We conclude that current incentives remain weak to support electromobility. The policies proved work to encourage electric mobility on motorcycles, but the most effective policy and key to speed up the transition is the replacement. Therefore, government policies to support electric mobility should consider, in addition to purchases of new motorcycles policies, policies focused on the current motorcycles in circulation that have an inertial effect on the market. But the replacement policies economic implications must be discussed: given that the population that accesses the purchase of motorcycles belongs mainly to low and middle socioeconomic strata, maybe non-economic incentives for replacement will not work, and a specific policy of subsidies may be necessary, which would be costly for the State but beneficial in terms of the externalities avoided by the rolling of combustion motorcycles.

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